Galactic Transients in the MeV Band

Liz Hays

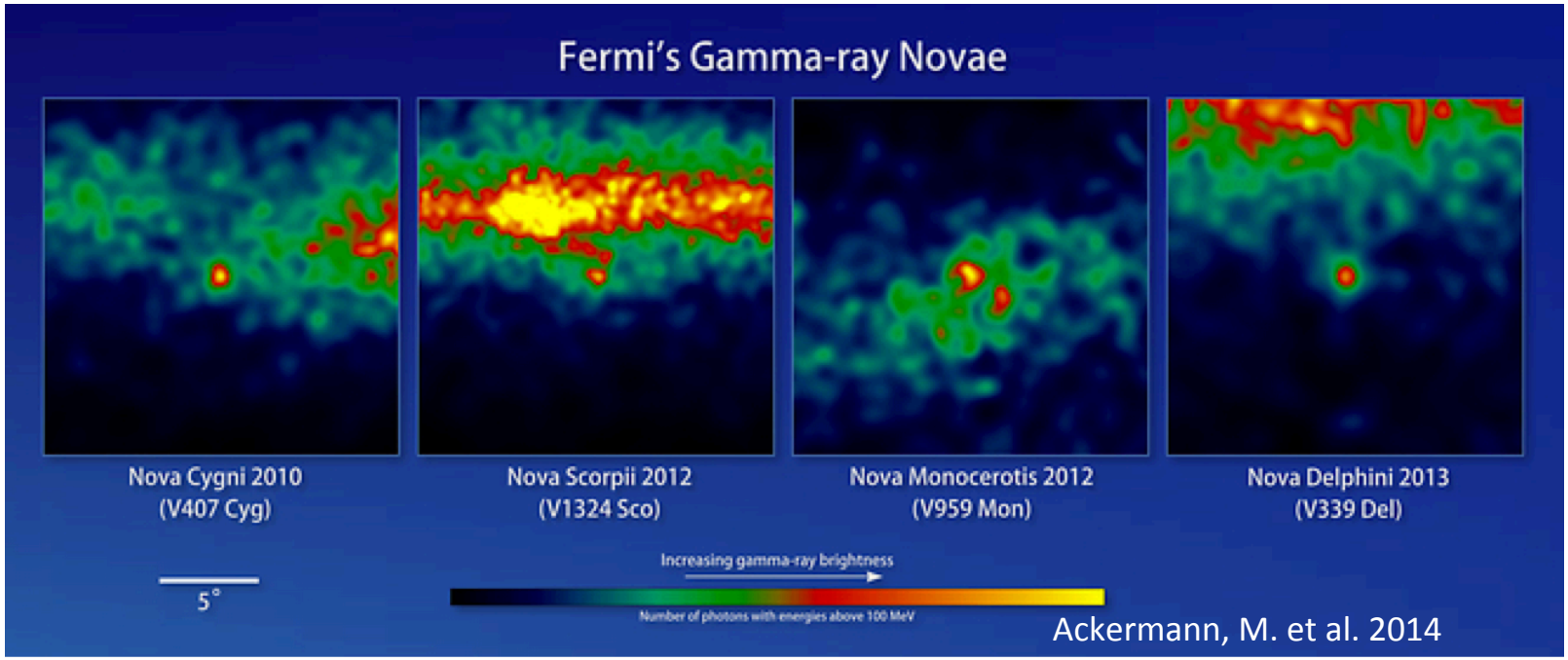
NASA GSFC

Galactic Variability in the GeV Band

- Compact Binaries
  - Gamma binaries (LS +61 303, LS 5039, HESS J0632, J1018 -- cyclical)
  - MSPs (pulsar/wind – transitional)
  - Cygnus X-3 (microquasar jet)
  - Novae (shock – true transient)
- Other
  - Eta Carinae (colliding wind binary -- cyclical)
  - Crab nebula flares (reconnection? -- repeats at random)
  - Solar flares (reconnection -- repeats at random)

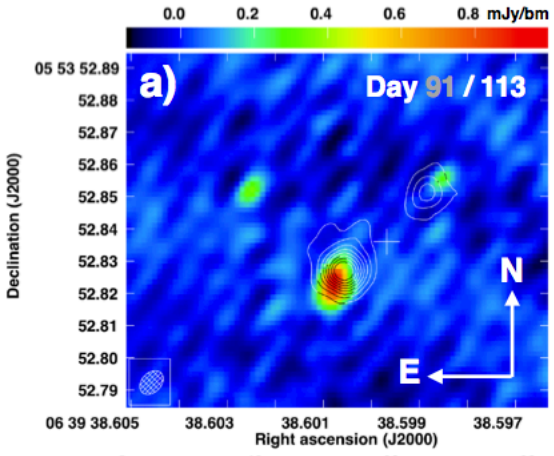
Novae

Nova shocks produce GeV particles



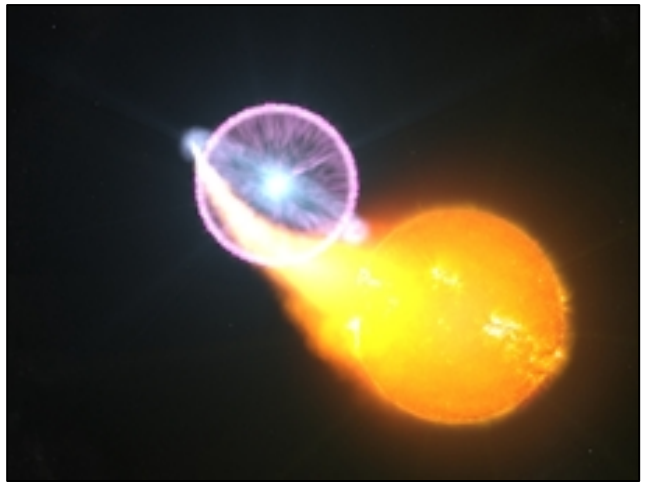
Ackermann, M. et al. 2014

Symbiotic and classical novae produce gammas

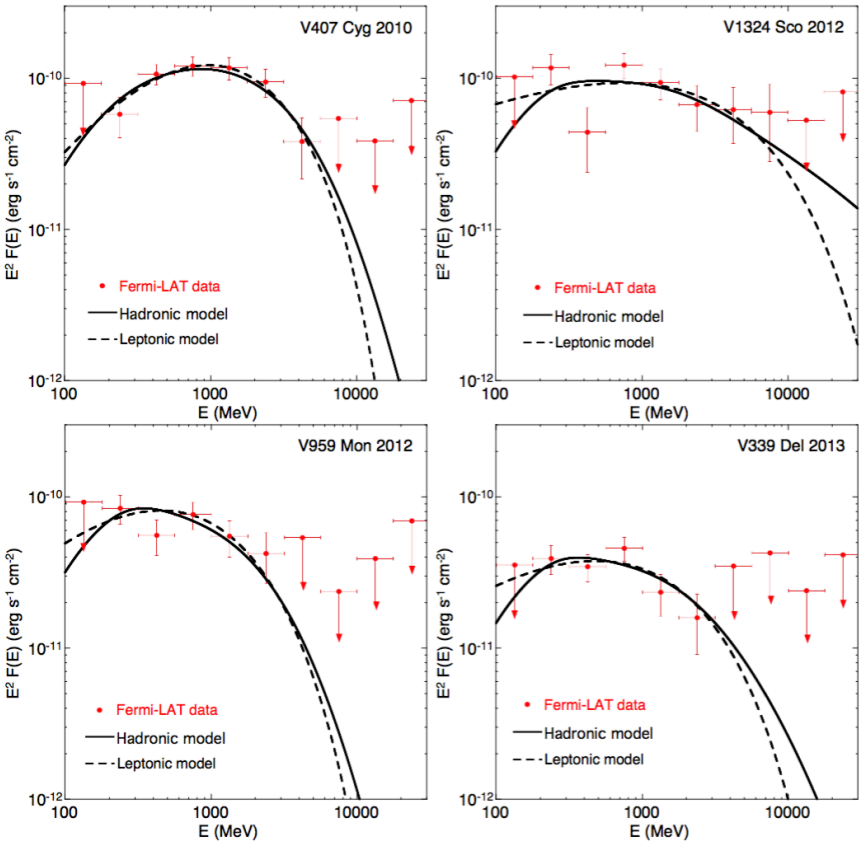


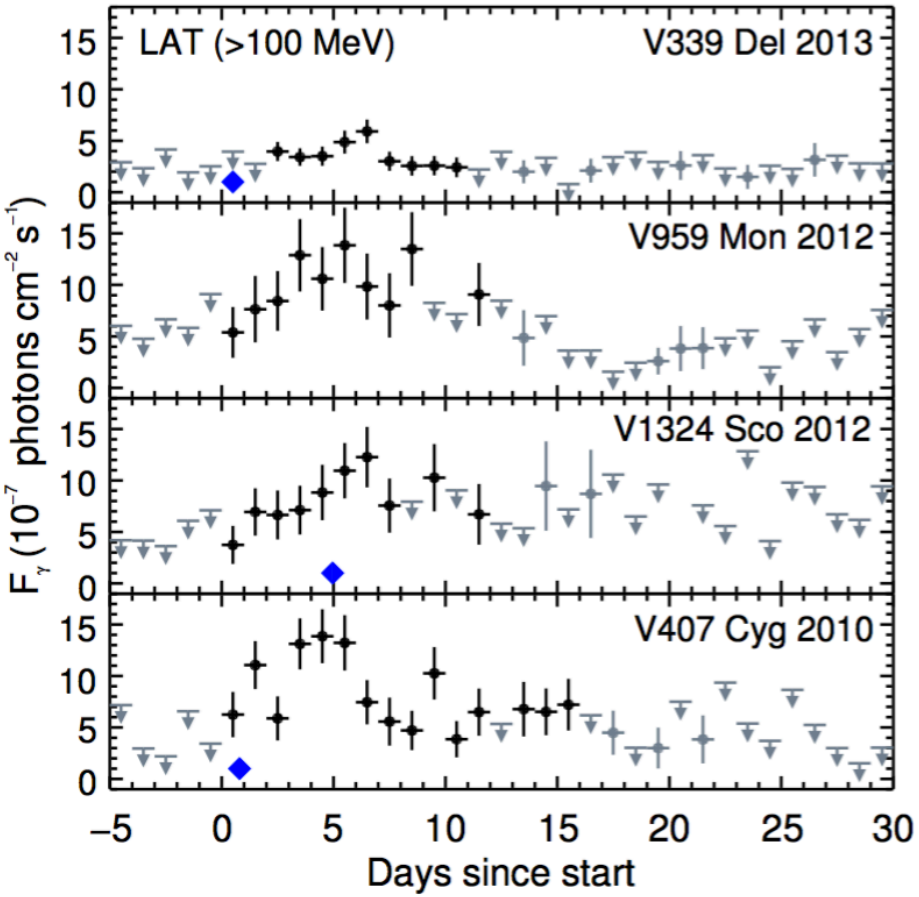
Radio imaging of expanding synchrotron emission

Chomiuk et al. 2014

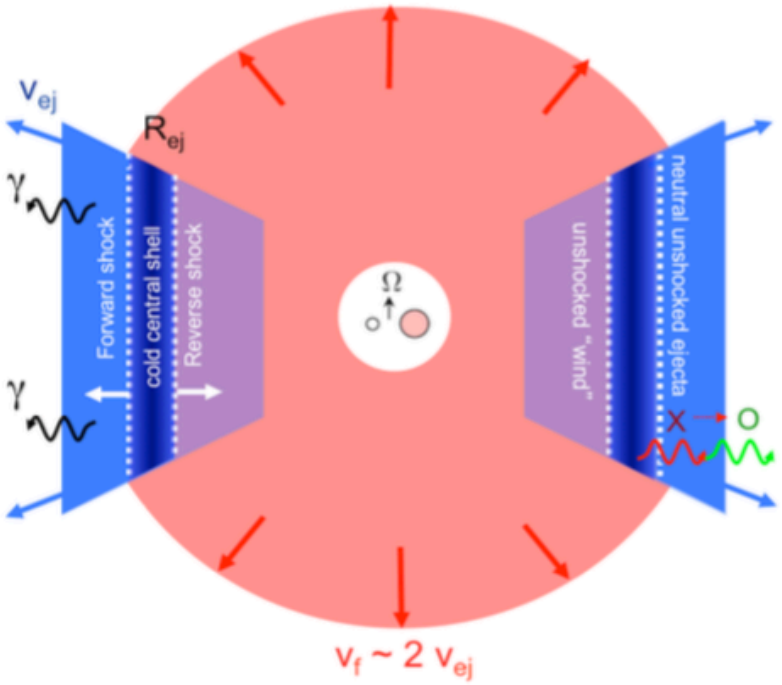


Gamma Characteristics





Tracking Evolution of Shock



Analog to core-collapse SN - novae provide possibility for time-dependent study of non-relativistic shocks using optical/UV/X-ray/gamma-ray lightcurves.

Ejecta provides a reasonably good hadronic calorimeter.

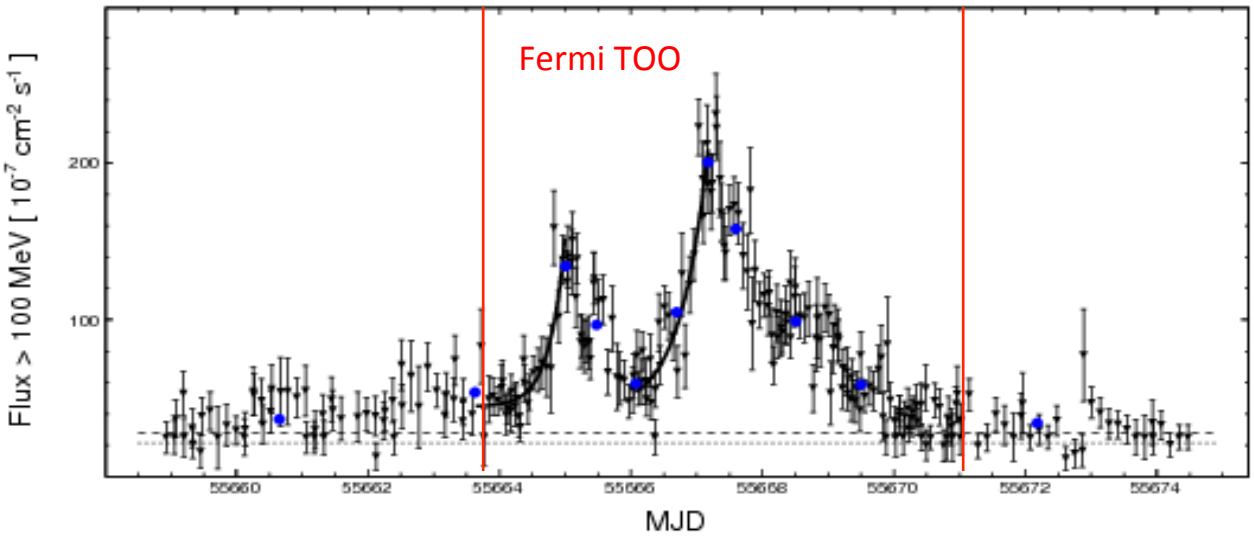
Metzger et al. 2015

Questions for MeV

- What is the shape of the spectrum below few hundred MeV?
  - Hadronic favored but not a clear case
  - SNR show an evolution from leptonic to hadronic
- Increased detection rate?
  - ~30-35/yr expected in the Milky Way. LAT observes ~1/yr. Some of this should be distance.
  - Enhanced angular resolution and sensitivity at ~100 MeV helpful in making detections in regions of higher Galactic background
- Extended gamma-ray lightcurve
  - Hints of extended lightcurve, but at threshold for LAT
- Some conclusions:
  - Sensitivity sub-100 MeV important for characterizing spectrum and expanding population (more chances to track broadband lightcurves)
  - Angular resolution important to distinguish in brighter regions of Galaxy

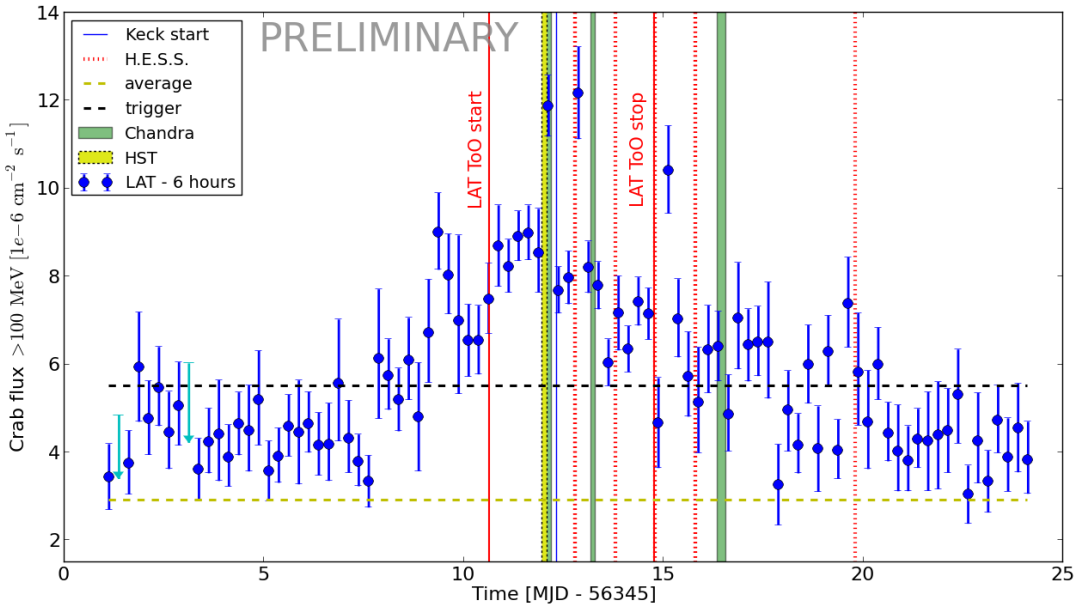
Crab Nebula Flares

Crab Flares: Extremely Rapid Variability



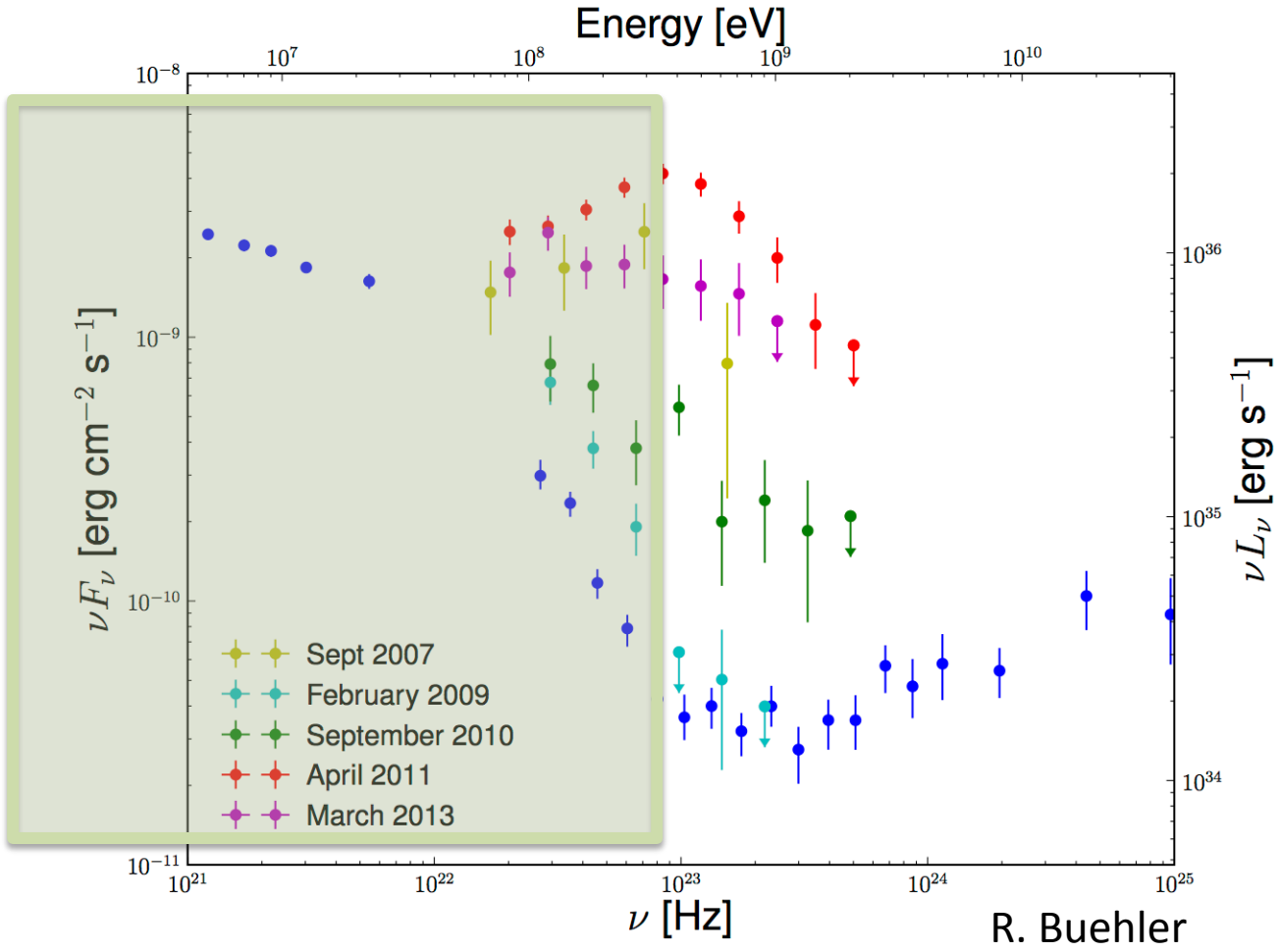
Buehler, R. et al. 2012, ApJ, 749, 26

Crab flux doubles as quickly as **5-8 hrs.**



Meyer, M. et al. 2013, ApJL

Pushing Limits of Particle Acceleration



Diffuse shock acceleration does not work

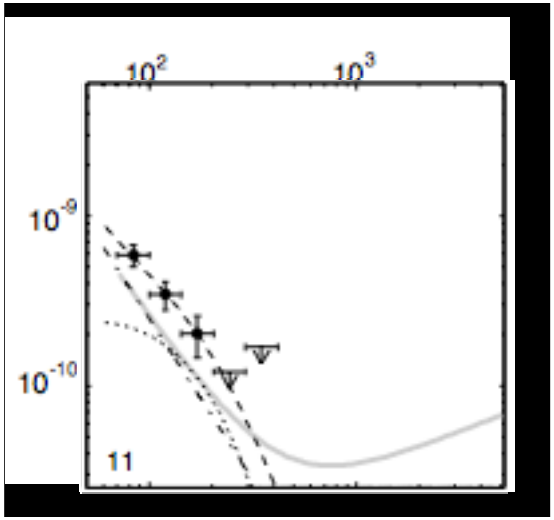
Flares are too fast!

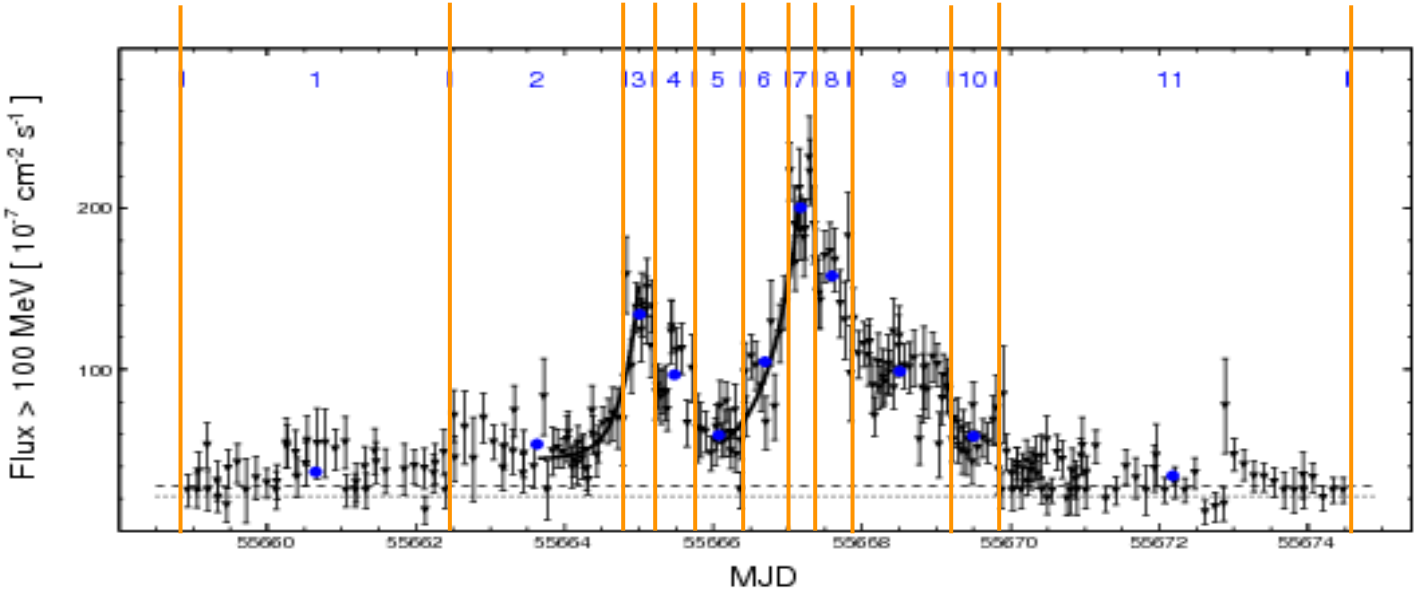
Particle energy exceeds synchrotron limit ~160 MeV

Strong evidence for reconnection

Crab Nebula: Spectral Evolution

Sufficient statistics in LAT to partition the spectral fit into 11 bins of constant flux (Bayesian Blocks analysis)





Flares from other PWN?

- Not crazy, but the Crab is a special object
  - Extremely high magnetic field
  - Extremely high peak energy for synchrotron peak (MSH 15-52 peaks lower but extends into MeV)
  - Nearby
  - Known for morphology changes in other bands

Questions for MeV

- What is sub-~100 MeV behavior of nebula during and following flares?
- Are/How are flares connected to longer time scale hard X-ray variability?
- What is the MeV variability?
  - Hard X-ray/soft gamma monitoring studies currently have low sensitivity on short timescales

Thoughts for the Future

- With moderate resolution, good prospects for transient studies near the Galactic plane
  - LAT variable sources are mainly identified
- In general LAT has detected variability for sources peaking in the LAT band – nonthermal sources tend to be variable -- good prospects for discoveries in source classes not observed by LAT, e.g. SGRs/magnetars, microqusars, accreting pulsars
- Angular resolution is a useful tool for Galactic studies, even for transients